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Stabilization of organic carbon in salt marsh sediments: A physical protection perspective

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1. Overview

Salt marshes are globally significant repositories of organic carbon (OC), and have received attention as potential locales where anthropogenic CO_2 could be sequestered through marsh production and accretion. However, unlike organogenic (peaty) marshes that only receive OC input from local production, minerogenic marshes receive OC from both autochthonous and allochthonous sources, complicating the relationship between local CO_2 fixation and OC burial. Therefore, our project addresses the following questions: What is the relative importance of autochthonous and allochthonous OC buried in minerogenic salt marsh sediments, and what are their likelihoods for preservation during burial?

To help distinguish allochthonous OC from autochthonous OC, we: (1) separate bulk sedimentary OC according to density; and (2) examine OC dynamics in areas dominated by C4 production. Density fractionation allows gross separation of low-density organic detritus (dominated by autochthonous OC) from mineral associated OC (assumed 100% allochthonous at time of deposition). Conducting the work in zones under C4 macrophyte cover (in this case *Spartina foliosa*) allows the use of $\delta^{13}C$ signatures to distinguish autochthonous from allochthonous (predominantly C3) OC endmembers.

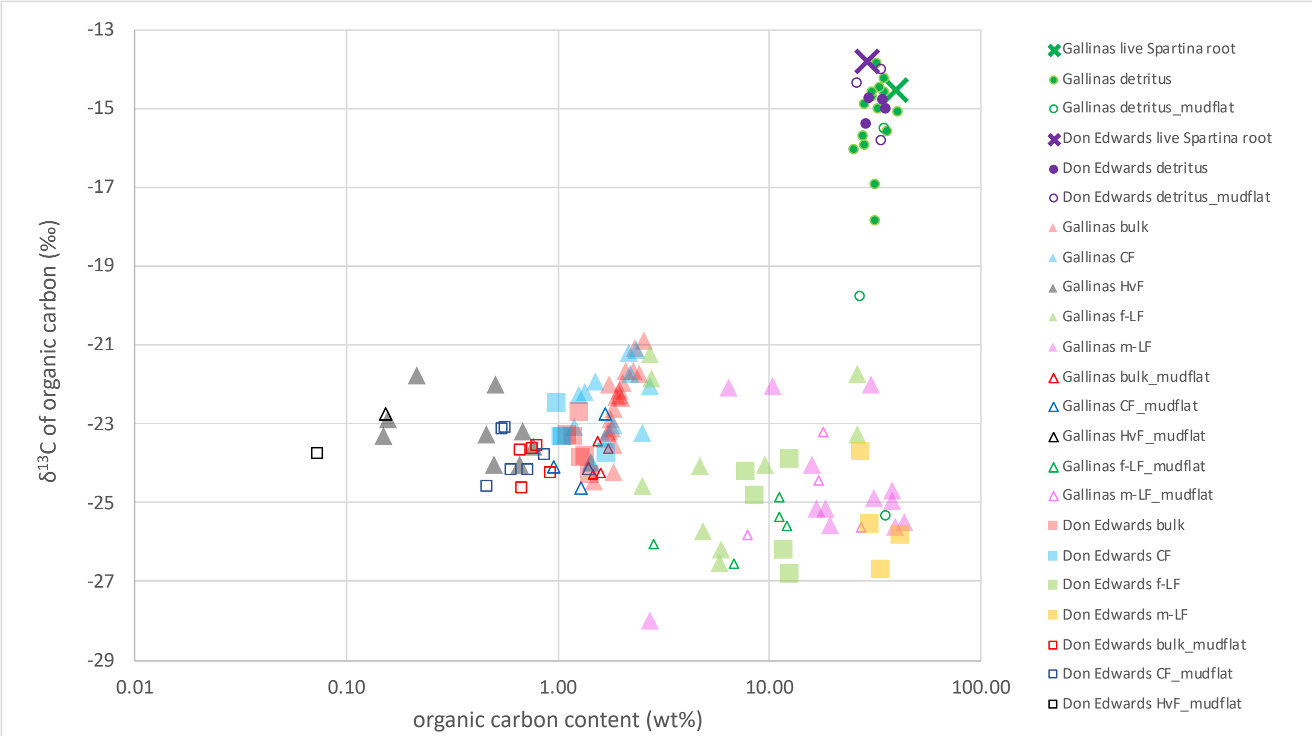
2. Summary of progress made during the reporting period (Yr-3, 9/1/18 – 8/31/19)

<u>Summary of activities:</u> Our efforts focused on processing the samples generated during Yr-2 for isotopic analyses. At the end of Yr-2, our dataset was limited to isotopic results from a single sediment core retrieved from the Spartina zone from our Gallinas Creek site. The dataset now includes 81 new $\delta^{13}C$ values from 4 additional sediment cores from two sampling sites. It also includes data from both Spartina zones and nearby mudflats (used as control in this project). We have also obtained $\delta^{15}N$ and $\delta^{13}C$ values of 27 detrital material (>2-mm) and plant tissue for end-member characterization. Despite our efforts, sample processing is not yet complete, and will continue into Yr-4 (no-cost extension). The primary goal for Yr-4 will be to obtain $\Delta^{14}C$ values for select samples, and to prepare manuscripts for peer-review.

<u>Highlights of findings to date:</u> Results reported herein concern the following density isolates: **fLF** (low-density particles that float freely when dispersed in solution with density of 1.6 g/mL); **mLF** (low-density particles that float in solution with density 1.6 g/mL only after disrupting mineral disaggregates by ultrasonication); **CF** (particles with density between 1.6 and 2.5 g/mL presumably rich in clay minerals); **HvF** (heaviest fraction isolated in this procedure with density >2.5 g/mL).

The figure below displays the OC content (in wt%) and the $\delta^{13}C$ values of the OC (in ‰) for all density fractions obtained to date. These are from 3 cores from Gallinas Creek (2 cores under Spartina cover, and one from nearby mudflat); and 2 cores from Don Edwards Wildlife Refuge (Spartina cover and mudflat). Main findings:

- **OC input from autochthonous sources (here predominantly *S. foliosa*) appears to be relatively minor at both sampling sites.** Regardless of whether the core was retrieved from the Spartina zone or from the mudflat, the $\delta^{13}C$ values of density fractions (triangles and squares) are much lower than the $\delta^{13}C$ value of local *S. foliosa* biomass (purple and green crosses), and instead are much closer to the $\delta^{13}C$ value of estuarine seston (~-25‰). This is true even for the two low-density fractions (fLF and mLF). Detrital material (>2-mm) were the only components of the sediment matrix that exhibited $\delta^{13}C$ values that overlapped with *S. foliosa* biomass.
- **There is evidence for incorporation of autochthonous OC into the mineral-bound pool.** While allochthonous OC seems to dominate the sedimentary OC standing stock, elemental and isotopic values of the bulk sediment suggest incorporation of *S. foliosa*-derived OC into the mineral-bound pool. There appears to be a positive correlation between OC content and $\delta^{13}C$ values of bulk sediment from Gallinas Creek (red triangles), which is consistent with increasing OC content due to addition of ^{13}C-enriched OC from *S. foliosa*. The fact that this apparent positive trend is seen only at the bulk level could be due to loss of plant-derived OC during density fractionation. A series of mass-balance calculations will be conducted to further investigate this matter.



This figure shows $\delta^{13}C$ values of OC (in ‰) and the OC content (in weight-%, or wt%) of: live Spartina root (crosses), >2-mm detrital material (circles); and density fractions (triangles from Gallinas Creek site, and squares from Don Edwards Wildlife Refuge). Filled symbols indicate samples retrieved from the Spartina zone, and open symbols indicate samples retrieved from nearby mudflat.

3. Impact on students and PI

Impact on students: Two undergraduate students participated in this project during this reporting period: Mr. Anthony Bravo and Mr. Gavin Shields. Mr. Bravo, a URM student who was involved in this project from the very beginning, was instrumental in processing the density fractions for $\delta^{13}C$ analysis. Overall, exposure to research through this project undoubtedly helped him win an NIH MARC award in 2017, and also aided him in his applications to Ph.D. programs in chemistry. Mr. Bravo, who graduated this summer, was accepted into a physical chemistry program at Oregon State University with full funding, but due to family circumstances, decided to pursue a career outside of the sciences in his home turf of San Francisco. Regardless of career outcome, there is no doubt that this project had a tremendous positive influence on Mr. Bravo's education and professional training. Mr. Shields prepared the detrital samples for $\delta^{13}C$ and $\delta^{15}N$ analyses. He has also contributed to analyzing the existing dataset, and recently submitted an abstract to the American Geophysical Union Fall Meeting. If accepted, this will be his first time presenting at a professional conference, which will be a positive experience for Mr. Shields who plans to apply to Ph.D. programs in hydrology this fall.

Impact on the PI: As a sediment biogeochemist interested in carbon cycle processes, the PI has primarily focused on offshore sedimentary environments in her research to-date. This project provided an opportunity to expand her scope of work by applying her area of expertise to a new system: tidal wetlands and marshes. These vegetated habitats are arguably much more complex than offshore depositional environments, and so far, this project has proved to be a positive learning experience for the PI. This project has also allowed the PI to begin to establish connections with wetland scientists, opening doors for new, and potentially fruitful, collaborations. Publications that will result from this project will help the PI obtain a footing in a field that is currently dominated by ecologists.